Curriculum Vitae of Luís M. A. Bettencourt

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Theoretical Division [T-7]
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Present Appointments

Technical Staff Member [Permanent Research Scientist]
Los Alamos National Laboratory — Los Alamos, NM, USA
Theoretical Division
September 2005 – present.

External Professor
Santa Fe Institute — Santa Fe, NM, USA
June 2007 – present.

Research Professor
Arizona State University — Tempe, AZ, USA
Department of Mathematics and Statistics and
School of Human Evolution and Social Change
April 2007 – present.

Past Professional Experience

Technical Staff Member [Research Scientist]
Los Alamos National Laboratory — Los Alamos, NM, USA
Computer and Computational Division
March 2003 – September 2005

Senior Postdoctoral Associate at the Center for Theoretical Physics
Massachusetts Institute of Technology — Cambridge, MA, USA
December 2000 – March 2003

Slansky Distinguished Postdoctoral Fellow
Los Alamos National Laboratory — Los Alamos, NM, USA
Theoretical Division
March 2000 -- March 2001

Director's Postdoctoral Fellow
Los Alamos National Laboratory — Los Alamos, NM, USA
Theoretical Division [Theoretical Astrophysics, Condensed Matter & Statistical Physics]
November 1997 -- March 2000.

Postdoctoral Position at the Institute for Theoretical Physics
Heidelberg University — Heidelberg, Germany
Institute for Theoretical Physics
October 1996 -- November 1997

Education

Imperial College, University of London **London, UK**
October 1992 -- September 1996,
Ph.D. in Theoretical Physics December 1996.

Instituto Superior Técnico **Lisbon, Portugal**
September 1987 -- July 1992
Licenciatura [5 years] in Engineering Physics with First Class Honors.

Research Interests

Urban Organization and Dynamics, Population and Economic Growth, Sustainability

Real Time Epidemiology, Emerging Infectious Diseases and Pathogen Evolution

The Social Dynamics of Innovation and Scientific Discovery

Distributed Sensor Networks and Aridland Ecology

Memory and Information Processing in living Neuronal Networks

Fundamental Aspects of Nonlinear Dynamics, Statistical Physics, Complex Systems

Selected Recent Publications:

[from over 50 peer reviewed publications, see full list attached]

1. Bettencourt L. M. A., Lobo, J., Helbing, D, Kuehnert, C, and West, G. B., **Growth, Innovation, Scaling, and the Pace of Life in Cities**, Proc. Nat. Acad, Soc. (USA) 104 7301-7306 (2007).

2. Bettencourt L. M. A., Lobo, J. & Strumsky, D., **Invention in the City: Increasing Returns in Patenting as a Scaling Function of Metropolitan Size**, Research Policy 36 107-120 (2007).

3. Bettencourt L. M. A., Ribeiro, R. Chowell, G., Lant, T., and Casttillo-Chavez, C. **Towards Real Time Epidemiology: Data Assimilation, Modeling and Anomaly Detection of Health Surveillance Data Streams**, Lecture Notes in Computer Science **4506**, 79-90 (2007).

4, Chowell, G., Bettencourt, L. M. A., Johnson, N, Alonso, W. J., and Viboud, C. **The 1918–1919 influenza pandemic in England and Wales: spatial patterns in transmissibility and mortality impact** Proc. Royal. Soc. B **275** 501-509 (2007).

5. Bettencourt L. M. A., Stephens, G. J., Ham, M. I. and Gross, G. W. **Functional structure of cortical neuronal networks grown *in vitro*** Phys. Rev. E **75**, 021915 (2007).

6. Chowell G., Nishiura H. and Bettencourt, L.M.A. **Comparative Estimation of the Reproduction Number for Pandemic Influenza from Daily Case Notification Data**, J. R. Soc. Interface 4, 155–166 (2007).

Please, see my web page http://math.lanl.gov/~lmbett for highlights of research, brief descriptions of research themes, complete list of publications and a full CV.

Research News Coverage

To escape flu - move to the country **Telegraph.co.uk**

The urban organism **Nature News and Views**

If You Can Make it There: Cities Are the Greatest Generators of Innovation and Wealth

Scientific American

Big cities need a fast-paced life to grow **Nature News**

Innovation and Growth: Size Matters

Breakthrough Ideas for 2007 : Harvard Business Review

Ideas: the lifeblood of cities **New Scientist**

The Living City: A new science applies metabolism to the metropolis **SEED Magazine**
Modeling the Emergence and Development of Scientific Fields

U.S. Department of Energy: Office of Scientific and Technical Information

And several other features in American, German, Italian, Swedish, Norwegian and Portuguese news publications.

Prizes and Awards

Best Paper European Complex Systems Society annual meeting, October 2007.

Chosen (with 50 others out of over 200 applications, by essay) to participate in the Computer Research Association International Conference on "Grand Research Challenges in Information Security and Assurance", Airlie House, Warrenton, Virginia, November 16-19, 2003.

Slansky Distinguished Postdoctoral Fellowship, Theoretical Division. Los Alamos National Laboratory 2000, for interdisciplinary research.

Director's Postdoctoral Fellowship. Los Alamos National Laboratory 1998-2000.

Portuguese National Science Foundation (JNICT) Post-graduate Award, 1992--96, to conduct Postgraduate studies leading a PhD degree.

Fellowship for Young Researchers, between 1990-92 by INIC, the Portuguese National Institute for Scientific Research, while an undergraduate

Winner of Essay Competition for young Europeans (European Union wide) sponsored by the Japanese Ministry of Foreign Affairs on cooperation between Japan and E.U. Countries, August 1989.

Graduate supervision and teaching experience

Advised several Theses for GRAs at LANL in areas of applied mathematics, computer science, information theory and computational neuroscience.

Invited graduate lecturer at several international summer schools in complex systems and applied mathematics.

Set up MSc final research project on "Decision Theory, and the dynamics of trends" for

students at Imperial College, University of London, academic year 2003/04 under the supervision of Professor R. J. Rivers.

Graduate student research supervision at MIT-CTP.
Supervised Graduate student Yoav Bergner's thesis on the non-equilibrium time evolution of first order phase transitions in quantum field theory.
Yoav successfully defended his thesis in August 2003.

Supervisor for Summer Student at LANL. This is a Summer graduate program in which students have a change to experience research at LANL. June-August 1999.

Tutor at B.U.S.S.T.E.P., British Universities Summer School in Theoretical High Energy Physics, University of Sussex, Falmer, U.K. September 9-24, 1997. Tutors are selected among promising senior postdocs to cover the materials in the school's syllabus. These reflect the perceived basic and new exciting fields of high energy Physics and Cosmology. My field of expertise was non-equilibrium quantum fields.

Teaching Assistant in Dynamical Systems and Chaos, Imperial College, London, England. October 1994-January 1995.

Teaching Assistant in Quantum Mechanics, Imperial College, London, England. October 1993-January 1994.

Teaching Assistant in Thermodynamics, Instituto Superior Tecnico, Lisbon, Portugal. February 1992-July 1992.

Teaching Assistant in Classical Electrodynamics
Instituto Superior Tecnico, Lisbon, Portugal. October 1991-January 1992.

Assisted with final examinations for Physics undergraduates at the University of Heidelberg, between October 1996 and November 1997.

Other Scientific Activities

Member of Executive Committee of the Center for Non-linear Studies (Los Alamos National Laboratory)

Member of Search Committee Deputy Division Leader, Theoretical Division. Los Alamos National Laboratory.

Member of Editorial Board of "Mathematics in Computer Science" (Birkhäuser).

Consultant for Department of Energy, Office of Science and Technology Information (OSTI) on "Dynamics of Scientific Innovation and Discovery".

Member of the American Physical Society (APS), Society for Pure and Applied Mathematics (SIAM), Society for Neuroscience (SfN), and Society for American Archeology (SAA).

Scientific Committee of "International Conference on mathematical aspects of Computer and information Sciences" (MACIS 2006), Beijing, China, July 2006 and of several other

International conferences in Information Sciences, Computer Science and complex Systems.

Organizing Committee of “Opportunities and Challenges in Distributed Sensor Networks”, LANL/CNLS March 2006.

Organizer of "Information Processing in Complex Systems" Seminar series, held at the Center for Non-Linear Science, LANL.

Referee for Proceedings of the National Academy of Sciences (USA), Complexity, Physical Review Letters, Physical Review A, Physical Review D, Physical Review E, Physics Letters A, Annals of Physics, Physics of Plasmas, Journal of Statistical Physics, Physica A, Quantum and Classical Gravity, Journal of Artificial Societies and Social Simulation.

Scientific Secretary of School and A.S.I. in Current Topics in Astrofundamental Physics, Erice, September 1994.

Assistant Coordinator of A.S.I. in Electroweak Physics and The Early Universe, Sintra, March 1994.

Algorithmic and Computational Experience

Expertise in numerical methods for Ordinary and Partial Differential Equations, stochastic systems, nonlinear dynamics, statistical inference from data, Bayesian Statistics, time series analyses, scaling analyses, and graph theory.

I know Unix/Linux, OS X operating systems and Python, PERL, c, FORTRAN, HTML and several other data analysis, plotting and symbolic manipulation platforms: such as Mathematica, Maple, MATLAB, Data Explorer.

Language Proficiency

I have native proficiency in Portuguese and English. I have fluent communication skills in Spanish, French and German and good oral proficiency in Italian.

Full Publication List:

55. Identification of functional information subgraphs in complex networks
L. M. A. Bettencourt, Vadas Gintautas, Michael Ham, in review

54. "Detecting early human transmission of H5N1 avian influenza",
L. M. A. Bettencourt, and R. M, Ribeiro, in review.

53. "Quantifying social *vs* anti-social behavior in email networks",
L. H. Gomes, L. M. A. Bettencourt, V. A. F. Almeida, F. D. O. Castro, J. M. Almeida,
in review.

52. "On the transmission dynamics of knowledge" ,
A. Cintron-Arias, L. M. A. Bettencourt , D. I. Kaiser, C. Castillo-Chavez, in review.

51. "Population Modeling of the Emergence and Development of Scientific Fields"
Luis M. A. Bettencourt, D. I. Kaiser, J. Kaur, C. Castillo-Chavez, and D. Wojick,
Scientometrics (2008) in press.

50. Comparative estimation of the reproduction number for pandemic influenza from daily case notification data
G. Chowell, H. Nishiura, Luis M.A. Bettencourt J R Soc Interface **4**, 155-166 (2007)

49. "Separating the Wheat from the Chaff: Practical Anomaly Detection Schemes in Ecological Applications of Distributed Sensor Networks"
Luís M. A. Bettencourt, Aric A. Hagberg and Levi B. Larkey, in Proceedings of Distributed Computing in Sensor Systems (DCOSS 2007), (Santa Fe, NM USA), pp. 223--239, Jun 2007

48. "Towards real time epidemiology: data assimilation, modeling and anomaly detection of health surveillance data streams"
Luis M.A. Bettencourt, R.M. Ribeiro, G. Chowell, T. Lant, C. Castillo-Chavez
Zeng et al.(Eds.) Intelligence and security informatics: Biosurveillance Proceedings of the 2nd NSF Workshop, Biosurveillance, 2007.Lecture Notes in Computer Science. Springer-Verlag Berlin Heidelberg (2007).

47. "Growth, innovation, scaling, and the pace of life in cities"
Luis M. A. Bettencourt, J. Lobo, D. Helbing, C. Kuhnert, G. B. West
Proc Natl Acad Sci USA PMID 17438298 (2007).

46. "Invention in the City: Increasing Returns to Scale in Metropolitan Patenting"
Luis M. A. Bettencourt, J. Lobo, and D. Strumsky
Research Policy 36 107-120 (2007).

45. "The 1918–1919 influenza pandemic in England and Wales: spatial patterns in transmissibility and mortality impact"
Gerardo Chowell, Luis M. A. Bettencourt, Niall Johnson, Wladimir J. Alonso, Cécile Viboud, Proceedings of the Royal Society B: Biological Sciences

doi:10.1098/rspb.2007.1477 (2007).

44. "Spontaneous coordinated activity in cultured networks: Analysis of multiple ignition sites, primary circuits, and burst phase delay distributions"
Michael I. Ham, Luis M. Bettencourt, Floyd D. McDaniel, Guenter W. Gross, J Comput Neurosci. DOI 10.1007/s10827-007-0059-1 (2007).

43. "The functional structure of cortical neuronal networks grown *in vitro*"
L. M. A. Bettencourt, G. J. Stephens, M. I. Ham, and G. W. Gross,
Physical Review E **75**, 021915 (2007)

42. "New Opportunities in Ecological Sensing using Wireless Sensor Networks",
S. L. Collins, L. M. A. Bettencourt, A. Hagberg, L. Larkey, R. F. Brown, D.I. Moore, G. Bonito, K. A. Delin, S. P. Jackson, D. W. Johnson, S. C. Burleigh, R. R. Woodrow, and J. M. McAuley,
Frontiers in Ecology and the Environment

41. "Analysis of current Marburg virus hemorrhagic fever outbreak in Angola",
L. M. A. Bettencourt, LA-UR –05-3179, under revision.

40. "Tipping the balances of a small world",
L. M. A. Bettencourt, Submitted to Physical Review E.

39. "From boom to bust and back again: the complex dynamics of trends and fashions"
L. M. A. Bettencourt. Submitted to Journal of Artificial Societies and Social Simulation

38. "The power of a good idea: Quantitative Modeling of the Spread of Ideas from Epidemiological Models",
L. M. A. Bettencourt, A. Cintron-Arias, D. I. Kaiser, C. Castillo-Chavez,
Physica A 364 513–536 (2006).

37. "Improving Spam Detection Based on Structural Similarity"
L. H. Gomes, F. D. O. Castro, R. B. Almeida, Luis M. A. Bettencourt, Virgilio A. F. Almeida, Jussara M. Almeida.
In SRUTI: Steps to Reducing Unwanted Traffic on the Internet, July 7-8, 2005, MIT, Cambridge, MA, USA.

36. "Comparative graph theoretical characterization of networks of spam and regular email"
L. H. Gomes, R. B. Almeida, L. M. A. Bettencourt, V. A. F. Almeida, J. M. Almeida,
In CEAS 2005, July 21 & 22, at Stanford University, Stanford, CA, USA.

35. "The self-consistent bounce: an improved nucleation rate",
Y. Bergner, and L. M. A. Bettencourt,
Physical Review D 69, 045012 (2004).

34. "Dressing Up the Kink",
Y. Bergner, and L. M. A. Bettencourt,
Physical Review D 69, 045002 (2004).

33. "A step beyond the bounce: bubble dynamics in quantum phase transitions",
Y. Bergner, and L. M. A. Bettencourt,
Physical Review D 68 025014 (2003).

32. "Vortex description of the first order phase transition in the two-dimensional Abelian-Higgs model",
L. M. A. Bettencourt , and G. J. Stephens,
Phys. Rev. E 67, 066105 (2003).

31. "The role of point-like topological excitations at criticality: from vortices to global monopoles",
N. D. Antunes, L. M. A. Bettencourt , and M. Kunz,
Physical Review E 65, 066117 (2002).

30. "Relativistic hydrodynamic scaling from the dynamics of relativistic quantum field theory",
L. M. A. Bettencourt , F. Cooper and K. Pao,
Physical Review Letters 89, 112301 (2002).

29. "Critical Dynamics of gauge systems: Spontaneous vortex formation in 2D superconductors",
G. Stephens, L. M. A. Bettencourt and W. H. Zurek,
Physical Review Letters 88 137004 (2002).

28. "Dynamical behavior of spatially inhomogeneous relativistic $\lambda\phi^4$ quantum field theory in the Hartree approximation",
L. M. A. Bettencourt , K. Pao and J. Sanderson,
Physical Review D 65 025015 (2002).

27. "Langevin evolution of disoriented chiral condensates",
L. M. A. Bettencourt , K. Rajagopal and J. Steele,
Nuclear Physics A 693 825 (2001).

26. "The role of topological excitations at second order transitions".
L. M. A. Bettencourt , Invited contribution to Fluctuating Paths and Fields,
Festschrift Dedicated to Hagen Kleinert on the Occasion of His 60th
Birthday (World Scientific, Singapore, 2001).

25. "Properties of the Langevin and Fokker-Planck equations for scalar fields
and their application to the dynamics of second order transitions".
L. M. A. Bettencourt ,
Physical Review D 63 045020 (2001).

24. "Predicting the critical density of topological defects in O(N)scalar field theories"
N. D. Antunes, L. M. A. Bettencourt, and A. Yates ,
Physical Review D 64 065020 (2001).

23. "Ginzburg regime and its effects on topological defect formation",

N. D. Antunes, L. M. A. Bettencourt and W. H. Zurek.
Physical Review D 62 065005 (2000).

22. "The electrical conductivity in high temperature QED",
L. M. A. Bettencourt , E. Mottola,
Proceedings of ``Strong and Electroweak Matter 2000'', Ed. C. Korthals-Altes.

21. "Topological excitations and second order transitions in 3D O(N) models".
L. M. A. Bettencourt , Invited lecture. In the proceedings of
"Topology of strongly correlated system", Eds. J..Bicudo et. al. (2000).

20. "Shards of broken symmetry: Topological defects as traces of the phase transition dynamics",
L. M. A. Bettencourt , W.H. Zurek, J. Dziarmaga, and N.D. Antunes.
Acta Physica Polonica B 31 2937 (2000).

19. "Controlling one-dimensional Langevin dynamics on the lattice",
L. M. A. Bettencourt , S. Habib and G. Lythe,
Physical Review D 62, 1238 (2000).

28. ``Thermal vortex dynamics in a two-dimensional condensate'',
R. Sasik, L. M. A. Bettencourt and S. Habib,
Physical Review B 82 2824 (1999).

17. "Vortex String Formation in a 3D U(1) Temperature Quench"
N. D. Antunes, L. M. A. Bettencourt and W. H. Zurek,
Physical Review Letters 82 2824 (1999).

16. "The Length Distribution of Vortex Strings in U(1) equilibrium scalar field theory", N.D. Antunes, L. M. A. Bettencourt
Physical Review Letters 81 3083 (1998).

15. "Time Evolution of correlation function for classical and quantum anharmonic oscillators",
L. M. A. Bettencourt , C. Wetterich,
hep-ph/9805360.

14. "Time Evolution of Non-Equilibrium Correlation Functions",
L. M. A. Bettencourt, and C. Wetterich,
Physics Letters B 430 140 (1998).

13. "Thermodynamics of Cosmic String Densities in U(1) Scalar Field Theory",
N. D. Antunes, L. M. A. Bettencourt and M. Hindmarsh,
Physical Review Letters 80 908 (1998).

12. "Non-intercommuting Cosmic Strings",
L. M. A. Bettencourt , P. Laguna and R. M. Matzner,
Physical Review Letters 78 2066 (1997).

11. "Out equilibrium dynamics of quench–induced symmetry breaking and topological defect]formation",
N.D. Antunes, and L. M. A. Bettencourt.
Physical Review D 55 925 (1997).

10. "The Dynamics of Symmetry Breaking Phase Transitions",
N. D. Antunes, Luis M. A. Bettencourt.
In Proceedings of Sixth International Parallel Computing Workshop, Kawasaki, Japan, November 1996.

9. "Multiple-Scale analysis of the Quantum Anharmonic Oscillator",
C. Bender, and L. M. A. Bettencourt.
Physical Review Letters 77 4114 (1996).

8. "Multiple-Scale analysis of Quantum Systems",
C. Bender, and L. M. A. Bettencourt.
Physical Review D 54 7710 (1996).

7. "Non-equilibrium Evolution of Field Theories"
N.D. Antunes, and L. M. A. Bettencourt.
Proceedings of 5th International Parallel Computing Workshop, London, U.K., September 1995.

6. "Winding Number Correlation Functions and Cosmic String Formation",
L. M. A. Bettencourt, T.S. Evans and R. J. Rivers,
Physical Review D 53 668 (1996).

5. "Subcritical Bubbles and other Non-perturbative Configurations in the Electroweak Phase Transition",
L. M. A. Bettencourt ,
Proceedings of Fourth Workshop on Thermal Field Theories and Their Applications, Dalian, P. R. China, August 1995.

4.. "Coarse Grained Fluctuation Probabilities in the Standard Model and Subcritical Bubbles"
L. M. A. Bettencourt,
Physics Letters B 356 297 (1995).

3. "Interactions Between Local $U(1)$ Cosmic Strings: an Analytical Study",
L. M. A. Bettencourt , and R.J. Rivers.
Physical Review D 51 1842 (1995).

2. "Non-intercommuting configurations in the collisions of U(1) type I Cosmic Strings", L. M. A. Bettencourt , and T.W.B. Kibble. Physics Letters B 332 297 (1994).

1. "The Role of Local Defects in Cosmological Phase Transitions Interacting Cosmic Strings".
L. M. A. Bettencourt, Proceedings of Third Workshop on Thermal field Theories and Their Applications, Banff, Alberta, Canada, August 1993.

Brief Biographical Sketch

Luís M. A Bettencourt [Technical Staff Member, T-7, LANL] obtained his PhD from Imperial College, University of London, in 1996 for work on critical phenomena in the early Universe, and associated mathematical techniques of Statistical Physics, Field Theory and Non-linear Dynamics. He held postdoctoral positions at the University of Heidelberg, Germany, as a Director's Fellow in the Theoretical Division at LANL, and at the Center for Theoretical Physics at MIT. In 2000 he was awarded the distinguished Slansky Fellowship at Los Alamos National Laboratory for excellence in interdisciplinary research. He has been a Staff Member at LANL since the spring of 2003, first at the Computer and Computational Sciences Division (CCS), and since September 2005 in the Theoretical Division (T-7: Mathematical Modeling and Analysis). He is also External Research Faculty at the Santa Fe Institute, and a Research Professor at the Department of Mathematics and Statistics and the School of Human Evolution and Social Change at Arizona State University.

Dr. Bettencourt carries research in the structure and dynamics of several complex systems, with an emphasis on dynamical problems in biology and society. Currently he works on real time epidemiological estimation, social networks of human communication, distributed sensor networks, information processing in neural systems and urban organization and dynamics. He maintains many diverse multidisciplinary collaborations at LANL, and beyond at the Santa Fe Institute, ASU, Princeton University, Harvard, MIT, SAMSI, and UC Davis. He is a member of advisory committees for international conferences and referees for journals in physics, mathematics and computer science, and for international fellowship programs. In the last three years he has co-advised four PhD thesis, in epidemiology, complex networks, computational neuroscience and statistical mechanics. He is also a consultant for the Office Science and Technology Information of the US Department of Energy on the subject of scientific innovation and discovery.